DETAILED ACTION

Claim Objections

Claim 2 objected to because of the following informalities: As per claim 2, appending qubits to registers should be appending qubits to the approximation or eigenvector as the applicant does not mean to claim changing the structure of the quantum computer registers, but rather appending qubits to the end of a value stored in the register. For example, Figure 1 details a first register 110 with a first approximation, a second register 120 with qubit(s), The hadamard transform is performed on register 120, and then the qubits are appended to the approximation of 110 and stored in register 140, register 140 is not expanded in size from the appending; therefore, the qubits are appended to the first approximation, not the register holding the approximation.

Claim Rejections - 35 USC § 112

The following is a quotation of the second paragraph of 35 U.S.C. 112:

> The specification shall conclude with one or more claims particularly pointing out and distinctly claiming the subject matter which the applicant regards as his invention.

Claims 2-4, 5-6, 9, and 15 rejected under 35 U.S.C. 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention. Claim 2 recites ‘a method for computing an approximation of a vector’ comprising ‘storing a first approximation’ and ‘appending a qubit to the register that stores the first approximation’; it is unclear how storing a first approximation and appending a qubit to the register containing the first approximation

are computing an approximation of a vector. Specifically, the claim fails to distinguish that a 'second' approximation is generated. Explicitly reciting that the quantum computer register contains a second approximation would satisfy the requirement. As per claims, it appears to be out of order with regards to the disclosure of the specification, the qubit undergoes a hadamard transform prior to being appended to the first approximation, see Figures 1-2. Sufficient detail apparatus or elements must be recited to adequately describe and constitute the proposed method for computing an approximation of a vector. The claims are incomplete in that they recite only a portion of the methodology required for the method for computing an approximation of a vector to become operational, i.e., they omit essential elements and/or steps. See MPEP 2172.01. As per claim 5, it is unclear what vector is stored and how appending two qubits to the vector prepare an initial state. The claim language lacks context as per what vector is being used to prepare the state. As per claim 6, it is unclear how the state 'ket 0' and performing a Hadamard transformation on the qubit of state 'ket 0' prepares an initial state of a quantum computer. As per claim 9 and 15 it is unclear how appending two qubits to an eigenvector and taking the Hadamard transformation of the qubits results in an eigenvalue. Explicitly reciting that the quantum computer register contains a second eigenvector approximation would satisfy the requirement.

Claim 20 recites "a module stored on magnetic media". It is unclear what a module stored on magnetic media has to do with a quantum computing system or how it is to be used. Therefor claim 20 will not be treated on the merits.

Claim Rejections - 35 USC § 102

The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

> A person shall be entitled to a patent unless –
>
> (b) the invention was patented or described in a printed publication in this or a foreign country or in public use or on sale in this country, more than one year prior to the date of application for patent in the United States.

Claims 2-3, 5-6, 8-9 and 13-18 rejected under 35 U.S.C. 102(b) as being anticipated by "How Behavior of Systems with Sparse Spectrum can be Predicted on a Quantum Computer" by Ozhigov.

As per claim 2, Ozhigov discloses a method for computing an approximation of a vector, comprising: storing a first approximation of the vector in a quantum computer register; and appending a qubit to the quantum computer register that stores the first approximation of the vector (Page 676, column 1 lines 25-30 and column 2 lines 6-7, x is a first approximation stored in a register, 'a' is a qubit appended to x).

As per claim 3, Ozhigov discloses the method as recited in claim 2, further comprising: performing a Hadamard transformation on the appended qubit (Page 676, column 1 lines 25-30, performing the Hadamard transformation on at least one qubit).

As per claim 5, Ozhigov discloses a method for preparing a state of a quantum computer, comprising: storing a vector in a quantum computer register; appending at least two qubits to the vector in a quantum computer register; (Page 676, column 1 lines

25-30 and column 2 lines 6-7, x is a vector stored in a register, ‘a’ is at least two qubits appended to x) and performing a Hadamard transformation on the appended at least two qubits (Page 676, column 1 lines 25-30, performing the Hadamard transformation on at least a qubits).

As per claim 6, Ozhigov discloses the method as recited in claim 5, wherein: at least two of the appended qubits are in the state |0> (Page 676, column 2 lines 7-8, ‘a’ is is initialized to zero state [see also column 2 lines 24-26]).

As per claim 8, Ozhigov discloses a method for efficiently preparing the initial state of a quantum computer, said method comprising: storing a first eigenvector approximation in a quantum computer register; appending at least two qubits in the state |0> to the first eigenvector approximation (Page 676, column 2 lines 7-8, ‘a’ is is initialized to zero state [see also column 2 lines 24-26]); and performing a Hadamard transformation on the appended qubits (Page 676, column 1 lines 25-30 and column 2 lines 6-7, x is a first approximation stored in a register, ‘a’ is at least two qubit appended to x, Hadamard transformation is applied to ‘a’).

As per claim 9, Ozhigov discloses a method for efficiently preparing an initial state of a quantum computer for eigenvector approximation, comprising: obtaining a first eigenvector; placing the eigenvector in a quantum computer register; appending at least two qubits to the eigenvector in the quantum computer register; and performing a

Hadamard transformation on each of the at least two qubits (Page 676, column 1 lines 25-30 and column 2 lines 6-7, x is a first approximation stored in a register, ‘a’ is at least two qubit appended to x, Hadamard transformation is applied to ‘a’).

As per claim 10, Ozhigov discloses the method as recited in claim 9, wherein the at least two qubits are in the state |0> (Page 676, column 2 lines 7-8, ‘a’ is is initialized to zero state [see also column 2 lines 24-26]).

As per claim 13, Ozhigov discloses a method for approximating an eigenvalue of an eigenproblem with a quantum computer, comprising: obtaining a first eigenvector from a course discretization of the eigenproblem; storing the first eigenvector in a quantum register of size log N.sub.0 qubits (Page 676 line 1, length of register is log M qubits); appending at least two qubits in a second quantum register to the first eigenvector, wherein the at least two qubits are in the state |0> (Page 676, column 2 lines 7-8, ‘a’ is is initialized to zero state [see also column 2 lines 24-26]); performing a Hadamard transformation on each of the at least two qubits to derive a second eigenvector (Page 676, column 1 lines 25-30 and column 2 lines 6-7, x is a first approximation stored in a register, ‘a’ is at least two qubit appended to x, Hadamard transformation is applied to ‘a’).

As per claim 14, Ozhigov discloses the method as recited in claim 13, wherein the first eigenvector is obtained classically (Inherent, eigenvector is obtained from a classic approximation).

As per claim 15, Ozhigov discloses a quantum computing system for computing an eigenvalue, comprising: means for storing a first eigenvector in a quantum register; means for appending at least two qubits to the first eigenvector in the quantum register; and means for performing a Hadamard transformation on each of the at least two appended qubits to produce a second eigenvector (Page 676, column 1 lines 25-30 and column 2 lines 6-7, x is a first approximation stored in a register, 'a' is at least two qubit appended to x, Hadamard transformation is applied to 'a') means for computing the eigenvalue form the second eigenvector (Page 678 C2 L16-28 and 679 C2 L 1-8, the eigenvalue is computed from the approximated eigenvector).

As per claim 16, Ozhigov discloses the quantum computing system as recited in claim 15, wherein said additional qubits are appended while in a predetermined state (Page 676, column 2 lines 7-8, 'a' is is initialized to zero state [see also column 2 lines 24-26]).

As per claim 17, Ozhigov discloses a quantum computing system as recited in claim 16, wherein the predetermined state is the state |0> (Page 676, column 2 lines 7-8, 'a' is is initialized to zero state [see also column 2 lines 24-26]).

As per claim 18, Ozhigov discloses a quantum computing system, comprising: a first quantum register with size of at least log N.sub.0 qubits (Page 676 line 1, length of register is log M qubits), able to store an eigenvector; means for appending at least two qubits in a second quantum register, each of the at least two qubits in the state |0> (Page 676, column 2 lines 7-8, ‘a’ is is initialized to zero state [see also column 2 lines 24-26]), to the eigenvector; and means for performing a Hadamard transformation on each of the at least two qubits (Page 676, column 1 lines 25-30 and column 2 lines 6-7, x is a first approximation stored in a register, ‘a’ is at least two qubit appended to x, Hadamard transformation is applied to ‘a’).

Claim Rejections - 35 USC § 103

The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

Claims 11 and 19 rejected under 35 U.S.C. 103(a) as being unpatentable over Ozhigov in view of “A Two-grid Discretization Scheme for Eigenvalue Problems” by Xu et al. (hereinafter Xu).

As per claim 11, Ozhigov fails to disclose the method as recited in claim 10, wherein said first eigenvector approximation is obtained for an eigenproblem discretized on a coarse grid.

Xu discloses wherein said first eigenvector approximation is obtained for an eigenproblem discretized on a coarse grid (Abstract).

Ozhigov and Xu are analogous art in the field of generating eigenvalue approximations.

It would have been obvious to one of ordinary skill in the art at the time of the invention to implement the two-grid discretization scheme for determining eigenvalues as disclosed by Xu because it would allow for the eigenvalue approximation to generated with asymptotically optimal accuracy (quickly and accurately) and reduces the eigenvalue problem complexity (XU, Abstract and Introduction lines 11-17).

As per claim 19, Ozhigov fails to disclose the quantum computing system as recited in claim 18, wherein: the eigenvector is derived from an eigenproblem discretized on a coarse grid.

Xu discloses wherein said first eigenvector approximation is obtained for an eigenproblem discretized on a coarse grid (Abstract).

Ozhigov and Xu are analogous art in the field of generating eigenvalue approximations.

It would have been obvious to one of ordinary skill in the art at the time of the invention to implement the two-grid discretization scheme for determining eigenvalues

as disclosed by Xu because it would allow for the eigenvalue approximation to generated with asymptotically optimal accuracy (quickly and accurately) and reduces the eigenvalue problem complexity (XU, Abstract and Introduction lines 11-17).

Response to Arguments

Applicant's arguments filed 12/20/2011 have been fully considered but they are not persuasive.

Applicants argue on page 8 for claims 2-3, 5-6, 9, and 15 that the claims as amended satisfy the 112 2^{nd} rejections.

The examiner respectfully submits that the claims state a purpose in the preamble "a method for computing an approximation of a vector" or some derivation with the same general concept. The claim steps are storing a first approximation, appending qubits to the approximation, and performing a hadamard on the appended qubits. The examiner does not see that an approximation is computed. Claim language stating that the result sitting in the register is the approximation, or claim language detailing the additional steps required to generate the approximation would overcome the 112, because, as written, the claims do not satisfy the objective given in the preamble.

The applicant argues on pages 9-10 that Ozhgov fails to teach the applicants claims with regards to “appending [1 or 2] qubit(s) to the first approximation" because Ozhgov discloses dividing a main register into two parts, a main and an ancilla.

The examiner respectfully submits that Orzhgov details 2 separate memory elements: a main memory element [P671, C1, L31, U is in the main register] with the first approximation [P671, C1, L5, Eigenvalues of U], a second ancilla register [P671, C2, L10, ancillary register initialized], the main memory element having space (p bits) for the ancilla. Operations are performed on the main register generating the first eigen approximation [Eq 2, P676, C1], the ancillia are initialized [Citation above] and transformed [Eq 1, P676, C1], and the ancillia qubit(s) is/are placed in the register. Despite the words “appending" not being present, it is clear that placing the ancillary bits into the main register is an appending operation, as can be evidenced from the applicant’s own demonstration of Figure 1, Elements 110 and 120 combined at element 140 which has qubits reserved for both approximation and transformed.

Conclusion

THIS ACTION IS MADE FINAL. Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

A shortened statutory period for reply to this final action is set to expire THREE MONTHS from the mailing date of this action. In the event a first reply is filed within TWO MONTHS of the mailing date of this final action and the advisory action is not mailed until after the end of the THREE-MONTH shortened statutory period, then the shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of

the advisory action. In no event, however, will the statutory period for reply expire later than SIX MONTHS from the mailing date of this final action.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to KEVIN G. HUGHES whose telephone number is (571)270-3365. The examiner can normally be reached on Monday through Friday from 9am to 5pm.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Lewis Bullock can be reached on 5712723759. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/Lewis A Bullock, Jr./
Supervisory Patent Examiner, Art Unit 2193

/KEVIN G HUGHES/
Examiner, Art Unit 2193